

IMMEDIATE CHECK-UP DEVICES AND THEIR VALUE
IN LEARNING

by

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STATEMENT OF PROBLEM

Within the past eight years some few educators have busied themselves with a problem too long slighted-- that of providing students with an immediate knowledge of the rightness or wrongness of their responses-- and have set about to investigate the problem, apply to it the laws of mental activity, and develop devices and techniques as a means of carrying out their beliefs. In so far as the writer knows, no one has compiled a list of their achievements or attempted to draw from their patient innovations a semblance of form and order. It is the writer's intention, (1) to discuss briefly the chief devices and techniques which have been developed to foster immediate check-up, (2) to point out the findings of those who have conducted investigations into the beneficial effects of an immediate check-up and, (3) to present his own findings from an experimental investigation into the value of an immediate knowledge of the rightness or wrongness of a response as employed in a method of teaching by distributed reviews.

HISTORICAL SURVEY OF TESTING AND SCORING DEVICES

S. L. Pressey (23) has pointed out that education is the one major activity which has thus far failed to employ systematic ingenuity to the solution of its problems. Like other sciences, its development can be no faster than the development of its means of measurement and the development of its instruments.

While industry has been utilizing the machine to remove the monotony of its labors, educators have gone on with the routine of their offices, spending needless hours daily correcting tests when they might have been spared the monotony with increased accuracy of results and might more profitably have employed their time in actual teaching. And not only are tests time-consumers-- even the objective ones are wasteful since they can be used but once.

When Stone introduced the separate answer sheet eleven years ago in connection with his reading tests, he opened the way to test economy and offered an opportunity to do away with the page turning necessary to the location and correction of answers. He made possible, as well, convenient filing of test results apart from the bulky test pamphlets.

Since the introduction of the separate answer sheet, has come the development of testing, scoring and immediate check-up devices. That they have not developed towards any one goal by utilizing progressively the contributions of others will be evident from the historical survey of the devices which the writer offers. To him it is quite reasonable to assume that the inventors have, in the main, worked independently-- apparently not aware of more than a few of the previous competing educational instruments. It is the hope of the writer that his brief descriptions of the devices employed to the date of his writing will be of some value to laborers in the field of testing and scoring, by drawing their attention to what has been devised before them.

C. E. Lauterbach (9) patented an educational test sheet in 1926 which, though it failed to use a separate answer sheet, was a step towards simplification and speed in scoring. The five alternative answers per question were designated by numbers in close columns on the right of the sheet. The testee made his choice of the answers by crossing out the corresponding number. Upon the completion of the test the student corrected his own (or another student's paper) by placing a stencil key over the answers so that openings registered with the numbers on

the test sheet representing the correct responses. The number of cross-marks visible thus quickly became the score.

In 1927 T. E. Thompson (26) patented the first self-checking device. Its rather heavy wooden frame held in place a triple-ply arrangement consisting of a data sheet with its problem and answer location openings superimposed over a work-sheet. Directly under the work-sheet a check-sheet was placed, so designed that openings were provided under the incorrect answers. The pupil made his choice of the alternative answers, which were indicated by number positions on the data sheet, by pressing his pencil point through the holes which corresponded to his conception of the correct problem answers. When his selections were correct the pencil passed through the openings of the data sheet and slightly through the work-sheet before coming up against the correct answer stops, otherwise it penetrated all three layers of the device. Consequently the depth to which the pencil registered was an immediate indication of the rightness or wrongness of the response, and the work-sheet became something of a permanent record of the test results.

Two years later the Clapp-Young Self-Marking Tests (3) came out, ingeniously applying a separate folder for answers in such a way that by checking a square on page one corresponding to an alternative of the multiple-choice answers, use was made of a carbon strip on page three to record a print on page two. If the carbon cross fell in the answer square directly behind the original response (that is, on page two) the answer was correct. If the cross fell outside the square the answer was incorrect. The Clapp-Young answer sheet was also a forward step in testing in that the alternative positions for the whole test pamphlet were closely grouped on but two sides of the four page answer folder-- thus preventing much page turning.

F. B. Knight (7) has developed a test sheet having a row of spaced questions on one side and a similar row of answers on the reverse side-- the questions and answers being offset longitudinally to permit the sheet to be folded progressively from one edge towards the other in order to bring the answers adjacent to the corresponding row of questions. With the device it is also possible to prepare a space next to the question for the pupil's answer, and on the reverse side a space adjacent to each answer for a second trial. A variation of the test sheet permits the paper

to be folded progressively from the bottom to the top in order to bring the answers to the questions, which are written on the reverse side of the sheet, adjacent to the pupil's answer, or adjacent to the question if desired. Thus test scoring is facilitated and self-checking is possible.

Quite different is the device which S. O. Bondeson (1) prepared for testing students in arithmetic. It provides for an envelop containing a plurality of openings through which the pupil writes the answers to the problems adjacent to the openings. Behind the sheet upon which the answers are written is a sheet of cardboard to facilitate the insertion and removal of the paper, as well as to afford an adequate writing surface. As soon as a pupil completes a sheet it is removed to permit the other sheets within the envelop to be exposed successively to the new students to whom the envelop is passed. The sheets of responses are placed within a key envelop which allows the pupil's answers to appear through windows, adjacent to which are the correct answers to the problems. Quick comparisons are possible and the scores are readily obtained. As each paper is corrected it is removed and the other sheets appear successively adjacent to the openings.

Brownlee and Michner (a) copyrighted a separate answer sheet consisting of an envelop containing a stop sheet. The upper face of the envelop has rows of squares-- each row representing a question and each square an alternative answer. If the student thinks that answer two is correct, he cuts down the side and across the bottom of square two by pressing with a needle against the paper. He then turns the square upward and if the answer is correct he finds a mark on the back of the square. If the student fails to obtain the correct answer on the first attempt he tries the next most likely answer-- proceeding until he achieves the desired response.

A machine called Krexit has been designed by J. E. Roberts (b) to mark the correct answers of objective tests. A card is provided, containing squares numbered to correspond to each of the one hundred multiple answer questions and the testee checks the squares which he thinks represent the correct answers. The machine, which has been set to register the correct answer locations, marks the proper squares on the card with a red circle. Such a device

(a) Published by the inventors, Wichita, Kans. c. 1930
(b) Produced by the Educational Machine Co., Point Marion, Pa.

quickly shows the student the point of error as well as what the desired response should have been.

A device for self-scoring, much similar to that invented by T. E. Thompson, has been devised by J. A. Wiley (28). Its top plate is perforated in rows and columns and connected peripherally on three edges to the bottom plate. The envelop thus formed receives two slides, one having holes similar to the surface plate and the other having fewer holes, so arranged that openings occur below the correct answers and stops below the incorrect. A puncturable sheet is folded about the upper slide-- the fold inward. The two slides are then pressed within the envelop and the student tests his answers by pressing with a stylus upon the opening corresponding to the number of the multiple-choice answer which he takes to be correct. He is immediately informed as to the rightness or wrongness of the response, for the stylus will penetrate farther when the answer is correct than when it is incorrect. In case he punches the wrong hole he re-reads and re-punches as often as necessary. It is obvious that different stop-slides may be used to provide for different patterns of correct responses.

Among the test-scoring devices by S.L. Pressey is the "Pocket Tester and Scoring Corner" (23), the answer unit of which is a card containing a square for each of the numbered questions. The pupil writes the numbers of the alternative answers which he considers to be correct within the proper squares and the card is then pressed between two stencils which are closed on the left and bottom edges. The scoring-corner stencils have windows corresponding to the answer squares and the correct answers are marked upon the stencils at the side of each window. Scoring then becomes a matter of comparison of answers and of totaling the findings.

Pressey has also devised a machine (20) which automatically corrects and scores tests. The testee sits before the machine, reading the questions and alternative answers through a window. For each question he decides the number of the multiple choice answer which he thinks is correct and presses the correspondingly numbered key at the right of the window. By so doing he marks his choice and rotates a drum which moves his test sheet up to a new question. On the back of the machine a record is made of the correct responses. With this device it is possible, when teaching, rather than testing is desired, to move a lever which holds

the drum until the proper key has been pressed. The student will then know immediately the correctness or incorrectness of his response by observing the question on the drum. If he fails to move the question his answer is wrong. Accordingly, he re-reads and re-tries until he makes the proper response.

Two years later Pressey (21) further developed his machine to provide for automatic drill in problem solving. The action of the machine remained the same, except that a new release automatically omitted a question from further presentation after a subject obtained the correct answer twice in succession. The subject was instructed to continue his attempts at the correct answers while the test revolved about the drum as often as necessary, automatically dropping each question after two successive correct responses had been achieved.

Still a different machine (23) has been developed by the same inventor-- a machine which scores tests and tabulates them by item. It uses an answer plate consisting of two duplicate metal stencils which engage over typewriter paper when pressed together. Students indicate their answers by pressing a pencil through the squares in the metal plates which correspond to the alternative answers taken to be correct for the problems. The answer plates are then

run through a machine which provides for projecting pins corresponding to the correct answer holes. The pins are seated upon light springs which cause them to project through the punched holes, but to remain depressed by the paper if the holes are not punched. A carrier moves over the pins and the pins strike an item counter to rotate a counting ratchet one unit per pin-- the result is a total of the number of correct answers. A further application of the machine marks the positions of the correct answers which have not been punched. Still another feature of the device is the running total of those who have responded to the answers correctly. Pressey's machine operates as rapidly as one can swing the counter back and forth.

Without question the greatest number of devices for test correction and learning guidance-- and those destined to be most far reaching in significance-- are those developed recently by H. J. Peterson and J. C. Peterson. One of their earliest devices is a mechanical "Self-Instructor and Tester" (14) consisting of an opaque envelop with rows and columns of circles printed upon the surface-- each row representing a question and each circle in the row one of the alternatives of the multiple-choice answers. A hard, tough selector sheet with perforations so arranged that

they are located directly beneath the circles on the envelop which represent the correct responses, fits snugly within the envelop. On each side of the selector sheet is glued an intermediate perforated sheet having a hole for each circle on the tester surface. On each side of the selector sheet is placed a colored sheet of lightweight paper which serves to prevent the pupil from cheating by holding the device against the light to determine the location of correct answer spots and serves, as well, as a permanent record of the score. To operate the device the pupil presses a pin through the circle on the envelop which corresponds to his selection of the alternative answers. When the answer is incorrect the pin passes through one of the work-sheets and one of the intermediate perforated sheets to come to a stop against the selector sheet. When the answers are correct the pin passes entirely through the device. It may readily be seen that when the mechanical self-tester is desired as a teaching device the pupils may be instructed to re-read and re-try upon the event of a wrong initial response and proceed similarly until they gain a correct answer.

The Chemo-Score device (14), by the same inventors, has several forms-- yet in every case the same principle

is employed: the alternative answers (or characters representing them) are treated chemically in two inks of identical appearance which, when moistened or treated with a third chemical, stand out strikingly in different colors to notify the student of the correctness or incorrectness of his response. In one form the alternative answers, spots preceding the alternative answers or lines under-scoring them, are treated chemically with invisible inks capable of being brought out chemically into contrasting colors by the chemical or moisture in an absorbent strip comprising the core of a Chemo-pen. In another form-- and probably the form adapted to widest usage-- a separate answer sheet is treated chemically so that characters in rows and columns represent the alternatives of multiple-choice or true-false answers. The Chemo-Score device may be used for teaching, rather than for testing, purposes by instructing the pupils to re-read and re-try in the event of their failing to secure the correct color response upon the first attempt-- and proceeding similarly until they arrive at the proper answer.

The originators of the Chemo-Score device have applied their invention to pronunciation tests (19), psychological tests (12) and reading tests (13) in varied forms-- one of

which makes the test re-usable to the extent of the number of its detachable strips, and indefinitely beyond that time by the employment of Perfo-Score answer sheets. Since each strip carries chemically treated spots representing the alternative answers for the entire test, the test may be given to another person after the strip is removed, or it may be used for study purposes with each strip constituting a review.

Further evidence of the flexibility of the Chemo-Score technique is demonstrated in the distributed review workbooks of the writer. In his applications, chemically treated spots above the horizontally spaced alternative answers are visible in controlled fashion by the use of stencil key-cards. The previous results of study remain after the alternatives are attempted and self-emulation is accordingly promoted.

Quite similar to the Chemo-Score device is the Thermo-Score device (14) by the same inventors. It consists of chemically treated test sheets or separate answer sheets of the same general nature as the previously described device--except that heat, rather than a third chemical, brings out the color reactions.

In 1932 J. C. Peterson and H. J. Peterson copyrighted their "Perfo-Score Answer Sheet" (12) which has many of the advantages of previously mentioned scoring devices and an additional advantage of being almost negligible in cost. Numbers or characters representing the alternatives of multiple-choice or true-false answers are spaced in rows which correspond to the questions or problems. If the student considers the third alternative answer to be the correct one for problem number two he draws a circle around that character. Upon the completion of the test the various papers are collected and stacked upon a peg board-- the pegs of which fit into holes in the margins of the sheets to hold them firmly in alignment. The teacher corrects the papers by placing a key sheet (merely a Perfo-Score sheet, as before, with the proper answers marked) upon the peg board and then pressing an awl through the correct answer locations. In this way fifty or more sheets may be scored simultaneously and so quickly that the test results may be returned to the pupil immediately after the examination. Such a rapid testing procedure compares favorably, in its educational advantages, to the immediate check-up which is possible when the Chemo-Score device is used.

A further development of the same idea resulted in the "Multiple Perforator" (16)-- a machine which receives fifty or more sheets simultaneously, holds them carefully into a stack alignment and perforates all of the correct answer positions in the stack with one stroke of a lever. It is possible to adjust the machine to accommodate any given arrangement of answer positions desired.

H. J. Peterson, J. C. Peterson and H. H. Higginbottom have invented an electro-score device (16) which scores a separate answer sheet electrically, marks the correct answers and stamps the total score upon each paper. The answer sheet differs from the Perfo-Score answer sheet only in that the alternative characters are pairs of squares which have been stamped with an electrically conducting ink. The pupil connects the pair of squares, which corresponds to his choice of the alternative answers, with a lead pencil line. The paper is then scored by feeding it into the machine. Mechanical contacts drop upon the squares which represent the correct answers. When a line connects these squares an electrical circuit is made across the carbon line and the device registers a unit change upon the counter mechanism. The total score is automatically stamped upon each sheet.

Another type of electrical test corrector called the "Markograph" (c) is now available. It utilizes a separate answer sheet in which numbered semicircles are cut free except for the diameter lines. These semicircles correspond to the alternatives of multiple-choice answers and the selection of the answers is made by folding back the representative semicircle. The sheet is then put within the correcting machine and each correct answer registers as a light. Since electrical contacts are placed over the correct holes, a dial can be made to register the total score.

L. P. Elliot (d) patented a self checking answer sheet in 1933 which consists of a sheet of paper folded longitudinally down the middle and perforated at the fold. The record side of the folded sheet has rows of numbers corresponding to the test questions, and laterally spaced perforated circles or squares corresponding to the alternatives of multiple-choice answers. The student tears off the perforated circle or square which represents his choice of

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- (c) Produced by the Electrical Test-Corrector Co.,
335 Marquette St. Ironwood, Mich.
(d) Published by the inventor, Manhattan, Kans.

the answers. If his choice is correct a character is visible on the test surface below the opening.

EXPERIMENTAL STUDIES

The Value of an Immediate Check-up in Learning

Among the first studies of the value of an immediate check-up in learning is one by J. C. Peterson (15) who conducted an experimental investigation on the value of guidance in learning by means of his chemo-score invention previously described. Reading material from Woodworth's *Psychology* (Revised) was divided into three different assignments accompanied by appropriate questions. The subjects, who were divided into an experimental and a control group of equal ability as rated by previous psychological tests, were presented with the questions accompanying Assignment A as a preliminary examination. Thereafter the experimental group studied another copy of the same list of questions with the aid of their text books and checked their answers on a separate chemically treated answer sheet by means of a Chemo-pen, while the control group proceeded similarly except that they used an ordinary pencil instead of the self-checking device. The same test was then repeated, after study, without the aid of references or texts, and score

differences were noted.

The results of the experiment showed that the twenty-three students of the experimental group gained three times as many points over their preliminary test score as did the twenty students of the control group and that the difference in the average gains was 5.33 times its own standard error.

Assignment B was then given to the same students in a similar fashion, with the exception that what had been the control group on Assignment A became the experimental group in Assignment B, and vice versa. The gains in favor of the experimental group agreed very closely with those found in the study of Assignment A.

A third assignment was given to test the flexibility of the knowledge gained as a result of using the tester device. Accordingly Assignment C was given after the fashion of Assignment A, differing only in the final test which was couched in new terms and presented orally. Again the results favored the experimental group with a difference in mean gains 4.30 times its own standard error-- indicating that the tester technique in no way hinders the transfer of knowledge to new situations and new problems.

In order to compare the effectiveness of two methods of instruction, (a) the ordinary written-lesson method and,

(b) the self-instructor method, B.H. Fleenor (6) conducted an investigation among 30 pairs of college students who were enrolled in a home-study course in Psychology at Kansas State College. The basis for pairing the students was a Pre-test on the basic subject matter of the course and a Word Relationship mental test.

In method (a) the student studied an assignment and wrote answers to the objective and subjective questions. In method (b) there was no written work what-so-ever. Chemo-Score answer sheets were used and the student made his choice of the objective alternative answers by pressing a needle, taken from a dilute solution of alcohol, through a spot on the chemically treated card corresponding to his conception of the right answer. He was immediately informed by a color reaction as to the correctness of his response. If he secured the wrong color he re-read and made another attempt, continuing until he obtained the correct answer. At the end of each assignment the card was returned to the Home-Study Office and explanations of questions which were not fully understood were called for.

As a final examination for both courses Woodworth's 400 objective questions, based on his Psychology (Revised), were given.

The results of the experiment showed that the self-instructor group scored a median grade of 309 out of a possible 400 as compared to 288 for the written-lesson group. The difference between the means was 21.23 ± 3.16 times its standard error and therefore significant. It is to be noted that the self-instructor group scored a median advantage 18 points over Woodworth's own group at Columbia Teachers College.

Fleener found that students with a high mental test percentile ranking profited more under the self-instructor method than did students with lower mental test percentile ranking.

He reports that "The reaction of correspondence students to the self-instructor method has been quite favorable. Many have said that the method spares them of the time-consuming drudgery of writing out lessons and that the time thus saved is utilized to better advantage in study. These students indicate that the uniqueness of the method compels and holds interest".

Experimental Investigation of the Writer

Problem. In order to ascertain the advantage or disadvantage which might be attributed to an immediate knowledge of the rightness or wrongness of a response in teaching, rather than testing, technique, the writer performed an experimental study in the sixth grades of the Bluemont and the Roosevelt schools, Manhattan, Kansas.

Materials and Method. Pertinent, instructive questions, designed to cover completely two geographical units, Canada and Mexico, were prepared and presented for the full time normally allotted by the schools to the study of the units. The questions were multiple-choice, with four alternatives, and so treated chemically that the pupil made his choice of the alternatives by touching a chemically treated spot with his chemo-pen. A 'W' stood out immediately when his choice was wrong and an 'R' when his choice was correct.

The 34 pupils in the Bluemont Schools studied Canada with the check-up questions and, simultaneously, the same unit was studied without the check-up questions by an equal number of pupils in the Roosevelt Schools. In similar fashion, Mexico was studied with the check-up questions in the Roosevelt Schools and without them in the Bluemont. Both schools being made up of children from essentially

the same social and economic background, no intellectual differences were to be expected.

The regular class-room instructors were in charge of their pupils at all times and were instructed only in the use of the materials given and the standard modes of procedure. At the completion of each unit an objective test, made up of true-false, completion, and multiple-choice questions, prepared by a competent, disinterested third person, was presented by the instructors as a final examination over both units.

Where check-up questions were used, four distributed reviews were provided. The first review was executed with text books and reference books in the hands of the pupils. If they failed to obtain the correct response with the first touch of the Chemo-pen they studied further and made another attempt. This process was repeated until the correct answers were obtained.

Shortly before the end of the class period the papers were collected and exchanged for others containing the same questions treated chemically in the same way. This constituted the second review and was conducted without the aid of textbooks. The third review was conducted three

days later and the fourth review at the end of the study of the unit. Each day new questions were added and reviewed until the unit was completed and the final examination given. Pupils were encouraged to keep a record of their previous review scores with the intention of self-emulation.

Results. Conditions which rendered the results of the Mexican unit incomparable prevent the consideration of half the writer's data. In the Canada unit, however, where controls were satisfactory, the school employing check-up question technique scored a mean of 80.65 ± 1.64 in contrast to a score of 67.68 ± 1.378 in the school using ordinary class room methods. This leaves a difference, in favor of the check-up technique, of 12.97 out of a possible 100. Since the probable error of the difference between the means is 2.144, the difference is 6.054 times its probable error and therefore statistically significant.

Table I
Comparison of Check-up and Non-Check-up Scores

	Group A	Group B	A-B
Mean	80.645±1.641	67.68±1.378	12.97±2.144
Median	83.5	65.0	18.5
Stand. Dev.	14.18	11.913	
Quartile 1	75.25	58.27	16.98
Quartile 2	84.937	67.18	17.757
Quartile 3	90.625	76.10	14.525
Skewness	-.603	.785	

An examination of Table I will reveal further evidence of the value of the immediate-check-up technique. In examining the table Group A designates the school using the check-up questions with distributed reviews and Group B designates the school teaching in the usual class-room fashion. It will be noticed that Group A has a median score of 83.5 compared to 65.0 for Group B and that, in contrast to the findings of Fleener, the group of middle ability profits most from the use of the check-up questions, with the lower quartile showing nearly as much improvement. The writer does not feel that his differences in quartile gains justifies the drawing of conclusions,

but he does wish to state that probably the self-checking technique is not limited to any one mental level, and that the type of questions, together with the teaching procedure used, will determine where the maximum advantage will fall.

The measure of skewness for the distribution curves of the two groups is particularly significant since both are decidedly skewed in opposite directions-- Group A being skewed to the right and Group B to the left. This shows that the test which was too easy for Group A was too difficult for Group B and that the test should properly have included more easy and more difficult questions-- indicating the difficulty of making a single test well fitted for both groups. From an examination of the curve skewness, it is to be inferred that had the final test been adequate the merits of the check-up question technique would have been more significant than the differences reveal.

EVALUATION OF CHECK-UP DEVICES

It has been pointed out that much time could be saved the teacher by the employment of certain testing and scoring devices which are now available. With the perfo-score device, for example, it is possible to score 75,000 answers per hour without mistake, and with the multiple

perforator, to score over a half-million. It is also possible to score, mark correct answers and stamp scores upon a 100-item answer-sheet in approximately seven seconds with the Electro-Score machine previously described.

That such labor-saving devices are sound psychologically and educationally is evident from an examination of the results of experimental studies which have employed them. Thorndike (27) states that "When a person learns the response by anticipation and confirmation, it is likely to form a sure memory." Such is precisely the technique of the immediate check-up. While the interest of the student in the question before him is at white heat he learns the correctness or the incorrectness of his response. By continuing his efforts until the right answer is obtained he experiences satisfaction and, according to the law of effect, strengthens the proper connections.

It is interesting to consider how an immediate check-up provides for the operation of Thorndike's other laws of learning. Consider the law of exercise: since the correct responses are the only ones which allow a pupil to proceed to the succeeding questions, it follows from mathematical probabilities that the correct responses receive the most exercise and consequently that their connections are

strengthened most. Finally, considering the law of recency, it may readily be seen that the correct answer is always the most recent answer, for after it is obtained, and not before, the pupil proceeds to the next question.

THE FUTURE OF SELF-CHECKING DEVICES

To the writer it seems that testing and scoring devices, particularly those providing for an immediate check-up on the accuracy of responses, will gradually but forcibly press their obsolete competitors from the field of learning. As the great mass of educators learn that such educational instruments are not only available but practicable, economical, and educationally desirable, they will, of a certainty, make use of the aids. By so doing, a new impetus will be given to further test development and education will profit tremendously.

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